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REPORT ON THE OCEAN SCIENCE AND TECHNOLOGY SECTOR OF THE OCEANS INDUSTRY OF BRITISH COLUMBIA

Economic and Commercial Analysis
Report No. 25

Fisheries and Oceans Pêches et Océans

Canada

REPORT ON THE OCEAN SCIENCE AND TECHNOLOGY SECTOR OF THE OCEANS INDUSTRY OF BRITISH COLUMBIA

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ABSTRACT

The Ocean Science and Technology Sector (OS&T) of the oceans industry in British Columbia operates on the cutting edge of technology research, development and application. The British Columbia OS&T Sector consists of approximately 130 companies employing about 1900 people. The Sector is dominated by small export-oriented firms. Within the Sector 63% of the firms have fewer than 10 employees and only 20% have more than 25 employees.

The OS&T Sector is supported by government policies and programs, particularly in the areas of R&D, export promotion, and tax incentives. Growth markets for this Sector are related to increased naval spending, and development of the Arctic and offshore oil and gas industry, with smaller markets developing in oceans research, marine transportation and salvage, tourist submarines, and deep sea ocean mining.

Growth of this Sector is inhibited by a number of structural and organizational factors. These factors include: undercapitalization; overreliance on government contracts; underdeveloped management and marketing skills; difficulty in penetrating export markets; lack of an effective industry association; and a scarcity of basic industry information to guide private and public investment decisions.

RÉSUMÉ

En Columbie-Britannique, le secteur de l'océanologie de l'industrie des océans se trouve à l'avant-garde de la recherche, du développement et de l'application des nouvelles technologies. Le secteur regroupe environ 130 entreprises qui emploient quelque 1 900 travailleurs. Il est dominé par les petites firmes à vocation exportatrice. En outre, 63 % des entreprises du secteur compte moins de 10 employés êt seulment 20 % en ont plus de 25.

Le secteur de l'océanologie est soutenu par des politiques et des programmes gouvernementaux, notamment dans les domaines de la recherche et du développement, de la promotion des exportations et des encouragements fiscaux. L'accroissement des dépenses dans le secteur naval et l'expansion de l'industrie des hydrocarbures offshore et dans l'Arctique représentent des marchés d'avenir pour le secter. De plus petits marchés sont en voie de se développer dans les domaines de la recherche océanographique, du transport maritime et de la récupération, des sous-marins de tourisme et de l'exploitation minière en eaux profondes.

Plusieurs facteurs d'ordre structurel et organisationnel freinent la croissance du secteur. Ceux-ci comprennent, entre autres choses, l'insuffisance de moyens financiers, une dépendance escessive à l'égard des marchés de l'État, des connaissances lacunaires en marketing et en gestion, la difficulté de percer sur les marchés d'exportation, l'absence d'une association industrielle efficace et le manque d'informations de base sur l'industrie pour guider les décisions dans le domaine de l'investissement privé et public.

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EXECUTIVE SUMMARY

Of all the countries in the world, Canada, bordering on three oceans, has the longest coastline and the second largest continental shelf. This offshore area supports Canada's oceans industry: companies which use the ocean's renewable and non- renewable resources such as fishing, aquaculture, mining, recreation, and oil and gas exploration and development; and companies which supply ocean users with goods and services such as shipping, shipbuilding, and a diversified range of highly specialized science- and advanced technology-based products. In 1987, the Minister of Fisheries and Oceans announced an Oceans Policy For Canada, the main strategy of which involves the promotion of the Ocean Science And Technology (OS&T) Sector.

The purpose of this report is to provide an overview of the OS&T Sector of the oceans industry of British Columbia, to position the Sector within DFO's overall oceans mandate, to speculate on the market outlook for OS&T products and services, and to analyze the factors which constrain the Sector's growth.

The Ocean Science and Technology (OS&T) Sector of the oceans industry in British Columbia consists of approximately 130 companies employing about 1900 people. This represents 30 per cent of private sector OS&T employment Canada-wide. The Sector is dominated by small export-oriented firms. Within the Sector 63% of the firms have fewer than ten employees and only 20% have more than 25 employees.

The OS&T Sector of the oceans industry operates on the cutting edge of technology research, development and application. It includes companies that develop new products and services, and/or new applications for existing products and services. Products include instruments, communications, remote operated vehicles, robotics, submarines, and diving and power systems. Services include consulting (hydrographic, oceanographic, engineering, chemical, etc), computing, and subsea construction. A characteristic technique used by small companies to survive and grow is to find and exploit market niches where the company is the sole supplier of a particular product line.

Technology development within the OS&T Sector is characterized by the spin off of new stand alone technologies, which often involve the establishment of new companies. Based on the historical record, each subsea company in British Columbia spins off, on average, two other companies.

The OS&T Sector is supported by government policies and programs, particularly in the areas of R&D, export promotion, and tax incentives:

-new product R&D can take several years and is very expensive. While some firms have been established independently, many others have depended on Department Of Fisheries And Oceans (DFO) R&D contracts during their crucial start up years. Between 1984 and 1986, IOS was the project authority on a total of 347 contracts worth $13.7 million, distributed among approximately 100 British Columbia firms. A number of firms also owe

their existence directly to product research undertaken by IOS. At the present time DFO is continuing to expand its role in supporting development of OS&T Sector R&D with implementation of its new Oceans Policy For Canada, specifically through: the establishment of a 23 member National Marine Council; the development of the Oceans Frontier Program; and the establishment of an Oceans Technology Promotion Office;

-a number of federal government programs designed to aid firms attempting to find export markets for their products are funded by the Department of External Affairs, and the Department of Regional Industrial Expansion. Programs including the Program for Export Market Development, the New Exporters to Border States Program and the Technology Inflow Program are designed to aid OS&T firms in their marketing initiatives and bring new technologies to Canada. All of these programs are used by firms in the British Columbia OS&T Sector; and

- the OS&T Sector is very sensitive to tax incentives and was negatively affected by the elimination of the Scientific Research Tax Credit in 1985. In spite of the cancellation of this program Canada's tax incentives for R&D activities are very generous both in scale of deductions and tax credits available. In a 1987 review, Canada ranked third after Singapore and Australia among industrialized countries in terms of tax incentives for research.

Growth markets for the OS&T Sector are related to increased spending on sophisticated naval defence systems, and development of the Arctic and offshore oil & gas industry:

-Canada's new defence policy calls for increases in defence spending. In order to modernize naval forces for operation in three oceans, a portion of these funds is to be used to construct twelve new patrol frigates. Underwater surveillance equipment and mine countermeasure vessels and equipment will also be in demand. The policy also resulted in the establishment of a Defence Industrial Research Program to help Canadian industry establish a technical base. B.C. firms already have strong technical capabilities in these areas; and

-important growth opportunities for the OS&T Sector will also be found in helping meet the challenges facing the Canadian oil and gas industry in developing its offshore Arctic fields. A trend is anticipated toward the development of smaller fields that require new technology.

Smaller markets will continue to develop:

-DFO oceans research is expected to generate a demand for instruments, communication systems and advanced scientific services that improve the quality, cost, and speed of data collection. Also, demand for OS&T products and services is expected to increase as coastal states begin to map their new Exclusive Economic Zones (EEZ's):

-the marine transportation industry will continue to provide a growing market for precision navigation and positioning systems, and for specialized equipment for Arctic vessels to deal with ice;

-demand for tourist submarines is expected to grow but the global market is probably quite small;

-demands on the OS&T Sector related to salvaging ships and cargoes of historic and commercial interest is also expected to grow but remain a very small market in total; and

-the demand for OS&T goods and services from the deep-sea ocean mining industry is unlikely to increase in the near future, due primarily to low metal prices.

A number of structural and organizational factors have been identified which are inhibiting the growth of the OS&T Sector in British Columbia. These factors include: undercapitalization; overreliance on government contracts; under-developed management and marketing skills; difficulty in penetrating export markets; lack of an effective industry association; and a lack of basic industry information to guide private and public investment decisions.

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INTRODUCTION

Of all the countries in the world, Canada, bordering on three oceans, has the longest coastline and the second largest continental shelf. This offshore area supports Canada's oceans industry: companies which use the ocean's renewable and non-renewable resources such as fishing, aquaculture, mining, recreation and oil and gas exploration and development; and companies which supply ocean users with goods and services such as shipping, shipbuilding, and a diversified range of highly specialized science- and advanced technology-based products. In 1987, the Minister of Fisheries and Oceans announced a new Oceans Policy For Canada, the main strategy of which involves the promotion of the Ocean Science And Technology (OS&T) Sector.

The purpose of this report is to provide an overview of the OS&T Sector of the oceans industry of British Columbia, to position the Sector within DFO's overall oceans mandate, to speculate on the market outlook for OS&T products and services, and to analyze the factors which constrain the Sector's growth.

OVERVIEW OF THE OS&T SECTOR OF THE OCEANS INDUSTRY OF BRITISH COLUMBIA

INDUSTRY SIZE AND STRUCTURE

The OS&T Sector consists of approximately 130 companies, employing about 1900 people. This represents 30 per cent of industry employment Canada-wide. The distribution of oceans industry OS&T firms across Canada is given in Table 1.

Detailed information on the OS&T companies operating in British Columbia is presented in Appendix 1. The data reveal that the OS&T Sector is dominated by small export-oriented firms. 63% have fewer than ten employees and only 20% have more than 25 employees. The larger diversified companies (greater than 25 employees) tend to be those with business activities outside the oceans sector. Only two OS&T firms had more than 100 employees.

TABLE 1

DISTRIBUTION OF OS&T FIRMS BY PROVINCE*

PROVINCE	PRODUCTS	SERVICES	TOTAL
Newfoundland	15	40	55
New Brunswick	1	4	5
North West Territories	0	1	1
Nova Scotia	24	80	104
Prince Edward Island	3	0	3
Quebec	10	31	41
Ontario	68	75	143
Alberta	8	44	52
BRITISH COLUMBIA	34	85	119
TOTAL	163	360	523

*This list includes all companies which generate ocean industry OS&T products and services - whether as a primary or as a secondary activity (Updata 1987, 3). The above information reports 11 fewer B.C. firms than documented in this paper.

DISTRIBUTION OF OS&T FIRMS IN BRITISH COLUMBIA

High tech companies tend to cluster in "Silicon Valley" type communities, where a pool of skilled labour and risk capital is developed. The original Silicon Valley in Central California is home to 2500 computer technology companies all within a 60 square mile area. The OS&T Sector in British Columbia follows a similar pattern with companies concentrated in the Southern Vancouver Island and Greater Vancouver areas, both major population centres and seaports. Company location also relates to the existence of government research institutions (including the Department of Fisheries and Oceans' Institute of Ocean Science, or IOS, located in Sidney on Vancouver Island; the Department of National Defence Research Establishment Pacific located in Victoria; and the Pacific Geoscience Centre located in Sidney), and the existence of ocean-focused college and university programs, and the vocational training programs offered by the British Columbia Institute of Technology located in Burnaby.

The growth of the submersibles sub-sector of the OS&T Sector demonstrates the importance of other locational factors. British Columbia's entry into the submersibles field started with the manned submarines of the PISCES class in the 1970's. From this beginning, a number of firms have grown that produce remotely operated vehicles (ROV's) and tourist submarines. The original companies' excellent reputation and the pool of experienced engineers and technicians which became established, both gave Vancouver an advantage in developing and marketing submersibles. These factors were supported by the

abundance of deep, clean, protected water for testing the prototypes and the availability of trained graduates from the local universities, colleges and technical institutes.

PRODUCTS AND SERVICES

The OS&T Sector of the oceans industry operates on the cutting edge of technology research, development and application. It includes companies that develop new products and services, and/or new applications for existing products and services. Products include instruments, communications, remote operated vehicles (ROV's), robotics, submarines, and diving and power systems. Services include consulting (hydrographic, oceanographic, engineering, chemical, etc), computing, and subsea construction.

In the OS&T Sector, a characteristic technique used by small companies to survive and grow is to find and exploit market niches where the company is the sole supplier of a particular product line. Because patent protection is ineffective due to ease of infringement, firms rely on being first in the market with a product uniquely tailored to demand, on high quality, on attentive service, and on establishing a network of contacts to provide a measure of market protection (Shaffer 1985, 43). For example, Novatech designs, manufactures and markets radio beacons and xenon flashers for ocean location of instruments. Their products are used widely but in small numbers. 95 per cent of their production is exported, with half sold in the US, and half in Japan and Europe. They recently received a large order from the Soviet Union and hope to expand in that largely untapped market (Corman 1987).

The development and maintenance of a market niche can provide a stable cash flow or "anchor" for the company. This "anchor" in turn enables the company to direct its resources toward the development of other markets for the same product or towards R&D leading to the development of new products.

A schematic of products and services generated by the OS&T Sector in British Columbia is provided in Table 2. Instruments are categorized into acoustic, electronic, and other and measure tides, currents, waves, water temperature, and salinity. For example, the acoustic scintillation flowmeter currently being developed is a device which measures channel flow. With this method, spatially averaged flows can be measured without placing instruments in the central portion of the channel. Because of this, the method is well suited to the measurement of flows in heavily travelled channels such as harbour entrances and navigable rivers. As well, an electronic integrated navigation system coupled with a shore based microwave system can plot and electronically monitor a ship's course to an accuracy of within two meters.

Communications is concerned with the transmission of data between instruments and their users. Product examples include sub-scubaphones, xenon flashers, fibre optics, and satellite communications. Scuba phones allow several divers to talk to each other and communicate with a surface vessel. Xenon flashers are high intensity lights with a visible range of up to four miles, designed for equipment location, recovery, and warning applications at sea or on land.

TABLE 2

PRODUCTS AND SERVICES GENERATED BY THE OS&T SECTOR IN BRITISH COLUMBIA

PRODUCT/SERVICE	EXAMPLES
Instruments	Acoustic Instruments: -scintillation flowmeter -ice profiler -sidescan sonar -transponder Electronic Instruments: -integrated navigation systems -electronic charts -computer generated maps -circuit board design - winch and particle counters - fibre optics - data loggers - conductivity/temperature/depth Other Instruments: -ocean heat probe -water sampler
Communications	-sub/scuba phone -xenon flasher -fibre optics -satellite communications -160 channel data logger
Remote Operated Vehicles (ROV's) / Robotics	-unmanned semi-submersibles -manipulator arms -telerobotic systems -assembly/dissembly systems
Submarines	-manned research submarines -tourist/recreational submarines
Diving Systems	-Newtsuit -atmospheric systems -saturation

TABLE 2 CONTINUED

PRODUCT/SERVICE	EXAMPLES
Power Systems	-solid polymer fuel cells -lithium batteries
Other Products	-lifting bags -inflatable pipe plugs -drifting buoys -automated weather stations
Services	Consulting: -hydrography -oceanography -engineering -chemical analysis - planning - surveying -ice research -bathymetric systems -pollution control
	Computing Services: -predictive modelling e.g.,on tsunamis -computer surveys -computer aerial mapping
	Subsea Construction: - pipeline trenching - island design

ROV's and robotics include unmanned and manned semisubmersibles and submersibles, and manipulators. These and other devices can be used to place and retrieve instruments on the sea bed, to conduct underwater geological studies, and to construct underwater oil and gas production systems. These products are also used by the defence industry for mine detection and neutralization. For example, the Dolphin is used to map the ocean floor and was designed to do accurate, cost effective hydrographic survey work under adverse conditions. The Hysub 5000 robot, the latest prototype in this field, is expected to reach a depth of 5000 meters suspended at the end of a specially-developed fibre-optic cable, capable of transmitting data as well as colour and black and white video images from the sea floor to the surface. The Hysub 5000 also has pincers capable of picking up objects from the ocean floor, while controlled by the ship-borne operator. Manipulator arms can stack blocks and align steel pipes while the operator watches via remote T.V. on the

surface.

Manned submarines are used for many purposes including research and tourism. Research submarines can be outfitted with manipulators, ROV's, cameras, sample carousels, collection baskets etc. to suit the needs of the scientist. Vancouver companies have produced some of the deepest diving civilian submarines with depth capabilities of 1000-2000 meters. For tourist submersibles, the prime objective is visibility. External high intensity lights are located around the periphery of the vehicle to give the passengers good illumination of subaquatic features. Tourist submarines are currently in operation in year round resort areas such as Grand Cayman Island, Guam, and the US Virgin Islands. These subs can accommodate about 16 passengers. More recently, larger submarines have been developed which can carry 36 people and dive to depths of 40 meters.

Diving systems include the Newtsuit, a controlled environment suit that allows divers to work for hours at depths of up to 300 meters without the need for decompression on return to the surface.

Recent technological innovation in power systems include solid polymer fuel cells and lithium batteries. The solid polymer fuel cell system produces about .5 volts @ 4000 Amps per square foot and is a small scale power source with potential for application in subsea propulsion, back up power for subsea installation, electric cars, and as a power source for any remote location. It is believed that this system could also be scaled up to satisfy larger power applications.

The OS&T Service Sector includes firms providing consulting services - in hydrography, oceanography, engineering, chemistry, planning, surveying, and ice research - as well as providing specialized computer, and subsea construction services. Among the range of services offered are remote sensing of data relevant to oceanic, sea ice, and iceberg conditions using satellite and aircraft imagery; development of computer models for application to practical problems such as pollutant transport and sea ice interactions; and image processing techniques specific to the marine environment to measure surface water reflection and temperatures, and ice movement.

SPIN-OFF TECHNOLOGIES

Technology development within the OS&T Sector is characterized by the spin-off of new stand alone technologies, which often involve the establishment of new companies. For example, in the Silicon Valley of California during a 21 year period (1965-1986) some 600 companies were traced directly to one company called "Fairchild". A recent report (Western Subsea 1987, 8-10 & 40) suggests, based on the historical record, that each subsea company in British Columbia will spin off, on average, two other companies. For example, although Horton Maritime moved to the US in 1981, four separate British Columbia companies were spun off between 1978 and 1985. All were started by former employees, and include Mesotech Systems (acoustics), Ballard Technologies (batteries & fuel cells), Offshore Systems (precision navigation), and TIAC (subphones). Aanderra Instruments Ltd. is responsible for the spin-off of another ten British Columbia companies. Another example of spin-off technology is the development in 1985 by Can-Dive of a 1-Atmosphere Hardsuit

which was later used for the design of a NASA space hardsuit.

THE ROLE OF GOVERNMENT SUPPORT

The OS&T Sector is supported by government policies and programs, particularly in the areas of R&D, export promotion, and tax incentives.

GOVERNMENT FINANCING OF R&D

New product R&D can take several years and is very expensive. While some firms have been established independently, many others have depended on DFO R&D contracts during their crucial start up years.

It has been suggested that IOS nurtured the west coast OS&T Sector. Few companies existed on Vancouver Island before IOS was founded in the early 1970's. Because the opening of IOS occurred at the same time as implementation of the federal "make or buy"[1] policy, a considerable amount of IOS research was available to be contracted out to the private sector.

A recent report (Department of Fisheries and Oceans 1988) has documented how the Department's Science activities have aided the OS&T Sector through direct contracts, unsolicited proposals[2], and non-financial technological support. Between 1984 and 1986, IOS was the project authority on a total of 347 contracts worth $13.7 million distributed among 111 firms. 90% of these contracts were awarded to British Columbia firms.

DFO also provided non-financial support to the Sector including: scientific and expert advice; ship time; meeting rooms; equipment for calibration; facilities for image processing and acoustic testing; library services; and trained personnel. Of the 347 contracts noted above, one third received non-financial support. This support had a total value of $1.0 million. In addition, the Department provided non-financial support to the universities including: supervision and training of graduate students; research time aboard ships valued at $462 thousand in 1983-84; and the use of facilities and equipment.

A number of firms owe their existence directly to product research undertaken by IOS. Shaffer (1985, 4) has reviewed a number of examples of technology transfer in which the basic R&D was conducted by IOS prior to industry taking over. In some cases technologies were taken over by firms at the concept stage. In others, products were developed by IOS to the stage of fairly detailed specifications. Yet others involved initial design and testing of a prototype at IOS prior to involvement by private firms. In all these cases industry realized a definite cost advantage because of IOS willingness to underwrite the cost of basic

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[1] The Federal "make or buy" policy encouraged Departments to let contracts to the private sector for required products and services.

[2] The 1989 federal budget resulted in the cancellation of the Unsolicited Proposal Program. In 1988-89 approximately 19 British Columbia OS&T firms received contracts valued at $4.5 million through this program and client Federal Departments.

research.

The federal government has recently announced a new Oceans Policy for Canada, including a number of strategies which directly support the R&D activities of the OS&T Sector, specifically through:

-establishment of a 23 member National Marine Council. Five appointees are from British Columbia, three from the private sector and two from the university community. The council has been formed to advise the Minister on oceans-related policies and issues, to provide him with private sector views on the oceans economy, and more generally to provide a forum for the exchange of views on the use, development, management and protection of Canada's oceans;

-development of the Oceans Frontier Program. Its purpose is to support the private sector in its drive to develop a world-leading ocean mapping capability, to develop an oceans information base, and to support ocean-related R&D. First step initiatives in British Columbia have included: $2 million to Quester-Tangent Corporation to purchase a hydrographic data logging system, to be installed in all Canadian Hydrographic Science Regions (Vancouver Sun June 25, 1988, G6); $1.1 million to Terra Surveys for hydrographic work in the Arctic; and $0.5 million to Seaconsult Marine Research of Vancouver for developing and demonstrating an operational remote radar sensing technique. Implementation of this program will substantially raise the level of DFO contracting out, to the benefit B.C. firms; and

-establishment of an Oceans Technology Promotion Office within DFO. The purpose of the office is: to develop new program initiatives to promote the oceans sector; to improve access to existing programs; to generally improve the effectiveness of government assistance programs by providing information to the private sector; and to facilitate joint government/industry/university ventures. For example a Multi-Year Marine Science Plan documenting current programs and activities of all federal governments departments was recently released (DFO 1988c).

Further details of the new Oceans Policy are provided in Appendix 2.

Meanwhile, at the provincial level, the British Columbia Ministry of Economic Development is in the process of establishing a Marine Robotics Committee with representatives from the universities, industry, and government. The committee is currently directing its energies to the possibility of developing a "state of the art" subsea ROV ("Spirit of British Columbia"). If the project proceeds, its estimated cost will be in the $15-$18 million range. A secondary objective of this committee is the formation of a provincial industry association.

EXPORT PROMOTION OF R&D PRODUCTS AND SERVICES

A number of federal and provincial government programs, designed to aid firms attempting to find export markets for their products, are funded by the Federal Departments of External Affairs (DEA) and Regional Industrial Expansion (DRIE). These include:

-Program for Export Market Development (DEA). The purpose of the program is to provide financial assistance to Canadian businesses that wish to participate in, or undertake, various types of international trade promotion and export activities including trade show attendance, project bidding, and establishment of export consortia. Although no data are available concerning extent of use by OS&T companies, many companies contacted indicated they use the program and find it effective;

-New Exporters to Border States Program (DEA/DRIE/provincial government). This is a hands-on training program designed to provide novices with basic information on exporting to the U.S. It is carried out on an ad hoc basis with companies invited to attend. For example, OS&T companies that are members of the Vancouver Island Advanced Technology Association were recently invited to attend; and

-Technology Inflow Program (DEA). This program established in the past two years, was designed to acquire new technology for Canada. British Columbia OS&T firms use the program, but no frequency of use estimates are available.

TAX INCENTIVES FOR OS&T FIRMS

The OS&T Sector is very sensitive to R&D tax incentives since it is R&D driven. In, general, tax incentives have allowed OS&T firms to survive during difficult periods. The elimination of the Scientific Research Tax Credit Program in 1985 negatively affected the OS&T sector. This program came under Section 37 of the Income Tax Act and entitled R&D firms to transfer their unused tax incentives to outside "investors". It was discontinued due to widespread abuse and has not been replaced. More recently, however, the government has improved the tax advantages associated with the one existing R&D Tax Credit Program by relaxing the eligibility criteria for qualifying R&D expenditures and by increasing the refundable amount.

A 1987 review of R&D taxation revealed that Canada's tax incentives for R&D activities for small firms are generous both in the scale of deductions and tax credits available. Canadian firms have always been able to deduct operational and capital R&D expenditures from their current taxable income or carry these deductions backwards or forwards to reduce their tax liability. R&D tax benefits to firms in Canada grew over twelvefold between 1975 and 1982, from $15 million to $190 million. The review ranks Canada third behind Singapore and Australia among industrialized countries in terms of tax incentives offered for R&D (Le and Wudwud, 1988).

The effect of the recent White Paper on Tax Reform (DOF 1987) is expected to be a reduction in the type and amount of R&D expenditures that can be claimed as tax credits. For example the federal government has reduced the investment tax credit for R&D from

100% to 75% of taxes payable.

THE MARKET OUTLOOK FOR OS&T PRODUCTS AND SERVICES

This Section describes the major markets for British Columbia OS&T products and services, and assesses their growth potential. A note at the end of the Section outlines the benefits that the OS&T Sector will gain from implementation of the Canada-US Free Trade Agreement.

OCEANS RESEARCH

Oceans research is primarily a DFO Science Sector activity. The equipment and services required to conduct oceans research range from platforms (e.g. ROV's, drifting buoys) to specific instruments for data collection (e.g. sonar, water samplers) and data storage and transmission systems. Advances in knowledge about the oceans depend on this type of technological development.

Canada is a leading nation in oceans research, along with the US, France, Japan, the USSR, the UK, the Netherlands and Norway. The UN recently defined the Exclusive Economic Zone (EEZ) to include all areas of the continental shelf, continental margin, and abyssal plane within 200 nautical miles of a coastal state. Since then approximately 73 countries including the US and France have declared their EEZ's, with that area now under their economic jurisdiction. Canada's declaration of its EEZ is under consideration.

The result has been a flurry of renewed commitment to oceans research, as demonstrated by the development of the Global Oceans Science Program (GOSP) in the US and the new Oceans Policy for Canada. Major initiatives currently underway include the US effort to map the seabed of its EEZ and the World Oceans Circulation Experiment (WOCE), in which DFO, and especially IOS has a role. British Columbia OS&T firms offer the specialized offshore development planning services that will be required by coastal states as they begin to map their new EEZ's. British Columbia firms are also capable of assisting offshore countries in upgrading their physical oceanographic programs in areas such as wave forecasting, numeric modelling, oil spill movements, and estuarine circulation. Instruments required for these programs include sensors, transmitters, and recorders.

The funding of oceans research by the federal government is expected to increase somewhat in the medium-term with the implementation of the Oceans Policy and its related strategies. These strategies may lead to the development of new projects, such as a continental shelf mapping program, but the emphasis of Oceans R&D will be on new instruments and systems that improve information and reduce the cost and time of surveys and experiments.

In spite of the renewed commitment to oceans research by a number of countries, and an increasing interest by coastal states in asserting control over their EEZ's, intense competition will make the international oceans research market difficult for British Columbia OS&T firms. Looking at both the domestic and the international market, it seems fairly safe to predict that the oceans research demand for British Columbia OS&T products and services will grow slowly over the next few years.

OIL AND GAS

Growth opportunities for the OS&T Sector will be found in helping meet the challenges facing the Canadian oil and gas industry in developing its offshore Arctic fields, its west coast fields, in conducting Environmental Assessment Reviews and in contingency planning activities. A trend is anticipated toward the development of smaller fields, which will require less long term investment but which will require new, specialized technology. For example, a new technology is being tested that will allow for winter drilling in the Arctic Ocean. Finally, ROV's and divers will continue to inspect, maintain, and repair existing offshore structures at home and internationally.

The offshore oil and gas industry has been a major market for OS&T subsea technologies and products. OS&T goods and services used in the oil & gas industry include subsea surveys for exploration and environmental monitoring; design and construction of underwater production systems; diving services; environmental aspects of exploration and development; and inspection, maintenance, and repair systems especially in areas with ice. Most of this demand is related to exploration and initial well development.

The British Columbia OS&T Sector has played a major role in Canadian offshore development, especially in the Arctic (Western Subsea 1987). However, in the past few years, depressed oil prices have reduced exploration and development expenditures internationally with a significant effect on the British Columbia OS&T Sector. Future demand will depend on the price of oil. In most non-OPEC countries, stable oil prices above $18 (US) per barrel are required before new exploration is viable. For example, in Canada, the Oslo and the Peace River oil sands developments become profitable at $20 (US) per barrel; the Lloydminster heavy oil upgrade becomes profitable at $23 (US) per barrel; and the break even point for developing the far north oil reserves is $25 (US) per barrel (Financial Post 1988, 4). Oil prices fluctuated between $14 and $19 (US) per barrel during 1988.

A Statement of Principles was signed for the Hibernia project in July 1988, laying out the elements of the agreement. Cost reducing measures are being considered as part of negotiating the binding agreement. Initial production remains scheduled for late 1995.

A moratorium on West coast offshore oil and gas exploration has been in place since about 1970. In 1984 the Federal and Provincial Ministers of Environment appointed a five member panel to conduct a public review. The panel released its report in 1986 recommending 92 terms and conditions to be applied when renewed exploration proceeds on the West Coast. Federal and provincial governments have accepted responsibility for ensuring relevant recommendations are implemented. The moratorium is expected to be lifted after the Pacific Accord is signed.

It is anticipated that the demand for Environmental Impact Assessments and contingency planning related to oil and gas activities will continue to grow.

Tax incentives provided an impetus for exploration and development in the past. In the 1970's, the Petroleum Incentives Program encouraged oil and gas exploration in frontier and

offshore regions. This program was recently discontinued, at a time when low oil prices had already depressed exploration and development activity.

A recent federal initiative, the Canadian Exploration Incentive Program, effective October 1, 1988, is designed to improve the ability of mineral, oil and gas resource companies to raise equity in the marketplace. The program is expected to benefit resource-based communities and regions of Canada, by delivering $210 million a year to the mining, oil, and gas industries. The impact of this program on offshore oil and gas exploration and development is unclear at this time but it is expected that a large proportion of these funds will go to land based exploration companies.

DEFENCE

British Columbia's OS&T industries have a strong technical capability in both subsea acoustics and ROV's, products and services that are indispensable for maritime defence operations.

Canadian defence policy will continue to be based on a strategy of collective security within the framework of the North Atlantic Alliance, including the continental defence partnership with the United States. Within this broad framework, defence policy will contribute to maintenance of strategic deterrence, credible conventional defence, protection of Canadian Sovereignty, peaceful settlement of international disputes and effective arms control. The government intends to take a number of initiatives. It will provide the navy with modern capable vessels for operations in the three oceans. Land and air commitments in Europe will be consolidated to provide a more credible and more sustainable Canadian contribution. The reserves will be revitalized and enlarged to assume a greater role in the defence of Canada.

The British Columbia OS&T Sector initially buoyed by the announcement of major increases in Canadian defence spending is shocked by the 1989 federal budget announcement which cancelled the $8 billion plan to buy as many as 12 nuclear-powered submarines and froze the 1989 defence budget at last years level.

Expansion of naval forces through the Canadian Patrol Frigate Project (12 new frigates to be constructed by 1996) will increase the market for OS&T firms. Underwater surveillance equipment and mine countermeasure vessels and equipment will continue to be in demand. For example, technology such as the scubaphone that allows several divers to talk to each other and communicate with a surface vessel have been sold to police and armed forces, who use phones for anti-terrorist activities.

In recognition that modern armed forces are dependent upon advanced technology for effective military operations, the Department of National Defence (DND) has increased R&D contract funds by sevenfold over the years 1977-1987. This level of increase is expected to continue. DND recently implemented a Defence Industrial Research Program specifically designed to help Canadian industry establish a technology base from which to meet the Canadian requirements for defence equipment and supplies. Canadian

technology will be incorporated into DND Planning and operations wherever possible in order to encourage and strengthen Canada's defence industrial capacity.

Outside Canada, the military market for OS&T products is extensive. However, Canadian companies have experienced difficulty in penetrating other foreign defence markets due to security and national procurement policies. Teaming up with large foreign companies has proven successful in procuring foreign defence contracts. Canadian firms currently have access to U.S. defence procurements under the Canada-US Defence Production Sharing Agreement.

RECREATION

Growth opportunities for the OS&T Sector will be found in meeting the recent demand for tourist submarines and in supplying ocean related information and equipment to recreational boaters, surfers and windsurfers. The recent use of manned submersibles to take tourists underwater began in the Caribbean in the early 1980's when Research Submersibles Ltd found that there was far more business renting out their Perry submersible to tourists than to research scientists. In 1985, the Vancouver-based firm Sub Aquatic Development Corporation launched a 28-seat submersible to be deployed in Grand Cayman. A second submersible was launched the next year for work in Barbados. From that point, the industry grew by leaps and bounds, with at least two other British Columbia companies entering the subsea tourism market. Other countries entering the race for a portion of this small market include the US, France, and Britain. A recent report (Western Subsea 1987, 28) estimates that 100 tourist submarines will be working worldwide by 1995. Although world demand for this product is currently small, it is estimated that British Columbia firms could produce about 50 of these units for a total value of approximately $125 million.

Recreational boaters, surfers and windsurfers are demanding an increasing amount of information on tide, temperature, and waves. In the US, a firm called Ocean Routes currently is meeting this demand by providing information on Oceanographic conditions over the phone to its clients. This service in unlikely to become privatized as long as AES retains full responsibility for weather and weather related activities. Additionally recreational boaters are requiring more high tech equipment such as electronic charts and speed logs. Demand for these products is expected to increase slowly.

MARINE TRANSPORT

The marine transportation industry requires two general product types both of which are produced by British Columbia OS&T firms. The first is precision navigation and positioning systems, and the second is specialized equipment for Arctic vessels to deal with ice. The market for both types of product is small but growing. The commercial fishing industry requires improvements in both vessel and gear technology and in fishing surveillance capability.

MARINE SALVAGE

Traditionally, the marine salvage industry has been involved with the recovery or demolition

of sunken vessels that pose a threat to navigation. This activity makes marginal use of OS&T products and services.

However, a new international market is developing using advanced OS&T technology to locate and salvage ships and treasures of historic and commercial value. A good example is the location of the Titanic and retrieval of some of its artifacts, including the ship's safe. It is estimated that there is a worldwide potential of approximately ten projects per year, and British Columbia could reasonably be expected to participate in two projects per year over the next 15 years. A typical project costs in the range of $1-5 million dollars (Western Subsea 1987, 33).

OCEAN MINING

Ocean mining includes both near-shore and deep-sea activities.

Near-shore mining involves dredging and placer operations for gold, tin, gravel, and silica sand. Near shore mining creates little demand for OS&T products and services.

By contrast, tremendous mineral resources are accessible only through the application of OS&T to deep sea mining. Seabed nodules are viewed as possible future sources of nickel, copper, cobalt, and manganese. The recovery technologies are not yet developed and it is likely that a different technology will be required for the recovery of each specific mineral. Most observers believe that the industry will not develop in the near future, although some governments are supporting preliminary research into exploration and mining techniques.

A moratorium on offshore mining exists in British Columbia and is unlikely to be lifted until the current administrative difficulties between the federal and provincial governments are resolved.

An International agreement on deep sea-bed mining and improved metal prices could open up deep-sea mining as an important market for OS&T goods and services in the future. For example, one of the largest deep water polymetallic sulphide deposits in the world is situated off the coast of British Columbia. However, current metal price levels will not justify development in the near term.

IMPLICATIONS OF THE CANADA-US FREE TRADE AGREEMENT

Since the late 1950's Canadian firms have had access to US defence procurements under the Canada-US Defence Production Sharing Arrangement which provides for free trade in defence-oriented equipment. It allows Canadian firms to bid on US defence contracts as if they were US firms. Specific classified contracts can be exempt. This arrangement is not affected by the Free Trade Agreement (FTA) signed in Palm Springs and Ottawa January 2, 1988.

A recent draft report (DFO 1988b) on the implications of the Canada-US FTA on the OS&T Sector suggests that the agreement will improve Canadian access to the large U.S. market and reduce technical barriers to trade. For example, it is suggested that the key

players in this Sector in the future will be small and medium-sized enterprises with highly specialized technologies and the flexibility to enter into production sharing and marketing arrangements with foreign counterparts. Industrial co-operation and technological exchange could benefit both Canada and the US through joint response to global market requirements. Market access costs associated with trade show participation, equipment demonstration and distribution of promotional materials may be reduced. The FTA will also allow some very competitive U.S. OS&T companies to operate in Canada.

FACTORS CONSTRAINING GROWTH OF THE OS&T SECTOR

This Section discusses the major structural and organizational factors inhibiting the growth of the OS&T Sector in British Columbia. These factors include: undercapitalization; overreliance on government contracts; under-developed management and marketing skills; difficulty in penetrating export markets; lack of an effective industry association; and a lack of basic industry information to guide private and public investment decisions.

UNDERCAPITALIZATION

Many small companies encounter difficulties in gaining access to the risk capital required to grow. The Vancouver Stock Exchange is not a fully satisfactory source of funds for OS&T firms. Access to other traditional local investment capital sources is hampered by a general lack of knowledge and experience in the financial sector regarding the OS&T Sector. As a result, many firms suffer from underfinancing, and are vulnerable to takeovers.

The Vancouver Stock Exchange (VSE), an international venture capital exchange for start-up companies, is not a fully satisfactory source of funds for OS&T firms for five main reasons: first, for small companies the time and cost involved in preparing a public offering and maintaining a position in the market places a heavy burden on the company's management; second, there is the potential for loss of control through takeover; third, the VSE deals with public offerings up to $2 million, and the Toronto Stock Exchange deals with those greater than $5 million - companies needing between $2 million and $5 million are unlikely to succeed in approaching either exchange; fourth, there are very few venture capital companies in Vancouver that provide funds for a public offering; fifth, although the VSE is experienced in dealing with junior resource companies, it does not comprehend the products, ideas or needs of high tech junior companies.

The lack of competition in the venture capital market in Vancouver also limits the number of OS&T companies that have the opportunity to obtain risk capital. In the US, venture capital is a more common source of funding. For example, information technology companies in the Silicon Valley can choose from 41 venture capital companies in Palo Alto alone, all of which are equal to or larger in size than Vancouver's largest venture capital company (Information Technology Committee of the Science Council of British Columbia 1988, 28).

Access to other traditional local investment capital sources is hampered by a lack of knowledge of, and experience with, the OS&T Sector among investors. Generally, conservative financial institutions will not lend funds because they do not have adequate

information about the industry, its growth potential, and more importantly, the risks associated with both the industry as a whole and individual products. At the very minimum, financial institutions, investors, and venture capitalists need evidence of a proven track record, a product with established patent protection and an identified market.

The result is that British Columbia OS&T firms are underfinanced and thus vulnerable to being taken over. Likely candidates are firms with established customers facing the high costs of moving from prototype to volume production. As a consequence of takeover, Canadian-developed technology may be purchased by foreign interests at a fraction of the cost of the initial R&D borne by Canadian private and public investors. Also, takeovers by foreign firms may result in products developed in Canada being manufactured abroad. For example, Norwegian interests (Simrad Subsea A/S) bought Mesotech Systems Ltd. of Port Coquitlam and acquired its world class underwater acoustic technologies. This equipment is now being manufactured abroad. From a company perspective, takeovers offer a chance to survive.

OVERRELIANCE ON GOVERNMENT CONTRACTS

Many firms in the OS&T Sector have developed as a result of winning government contracts. Over-reliance on government contracts can cause a number of specific problems for OS&T firms:

-companies incur significant costs in designing and presenting bids to meet government contract specifications;

-winning contracts is a hit and miss business, causing booms and busts for individual companies;

-firms may be encouraged to overcapitalize to win large contracts;

-slow payment on government contracts can cause cash flow problems;

-patents and other technology often remain the property of the Crown; and

-defence contracts often require the use of prescribed materials which must be quarantined in the plant causing firms to incur significant overhead and inventory costs.

In more general terms, companies that derive a major portion of their revenues from government contracts tend to have a short-term view of the future. It is difficult to make longer term plans, and this can give rise to personnel problems since it is often difficult to hire or develop specialized expertise for short-term projects. Ironically, reliance on government short-term contracts forces many OS&T companies to be risk averse, in an internationally competitive field where taking risks is normal.

UNDER-DEVELOPED MANAGEMENT AND MARKETING SKILLS

Many companies in the OS&T Sector were started by professional scientists and engineers with a strong entrepreneurial spirit and scientific skills. Attracted by the prospect of increased profits, and increased corporate stability through a broader product line, a number have decided to make the transition from working on contracts for the government, and adapt their research to consumer and industrial markets. This decision, however, may be fraught with difficulty for companies with limited managerial and marketing capabilities.

Contract-oriented firms who market their services to government require a knowledge of the government procurement function, and an understanding of the various departments' mandates and product needs. The firm then needs to develop proposals to provide specified products. To a large extent, the product wants and needs of the customer are known.

Making the transition from focusing on government contracts to conducting research for consumer and industrial markets is difficult. Problems in marketing, finance (the 'under-financing' problem described above), and human resource management are inevitable. Consumer markets must be analyzed; an appropriate product must be developed; and promotion, pricing, and distribution strategies must be developed. These functions are often ignored or done on an ad hoc basis. For example, R&D staff maybe required to perform financial, sales, and staff management functions for which they have no skills or training. Although these skills can be picked up in one to two years of on the job training.

Many firms experience difficulty in developing and implementing marketing plans for their products, particularly in the early stages of their company's growth when attention is necessarily focused on product development. The hiring of marketing expertise is further constrained by undercapitalization. Smaller companies may attempt to do their own marketing using their R&D staff by advertising in magazines and trade journals and by attending trade fairs. But as one entrepreneur said "there is more to attending a trade fair than simply setting up a booth and chatting to people." It is a systematic process that begins by obtaining lists of potential customers prior to the fair, includes an ability to differentiate potential customers from the viewers, and concludes with post fair follow-ups (Duplessis 1988).

DIFFICULTY IN PENETRATING EXPORT MARKETS

Because the domestic market for OS&T products is so small, many firms are also forced, early in their existence, to develop export markets in order to survive. This further stresses their financial and human resources.

Across all industries, companies exporting to the US have sales of $3-5 million, are financially stable, and are managerially mature. In contrast, OS&T companies are significantly smaller, and have a more tenuous financial and managerial base.

A firm intent on marketing its products or services to foreign governments is more likely to be successful if it has already penetrated the domestic market. Foreign governments

interpret purchases by the Canadian government as an expression of confidence in the firm and its products or services and are more likely to purchase.

For a firm to export successfully, it is important to have a business plan against which to measure performance. A plan, for example, may indicate when efforts to penetrate foreign markets should be continued and when the firm should try to cut its losses. A plan is also helpful in confirming the commitment of every level of the organization to an export strategy, which will take time before showing a pay off. With a plan in hand, and the full commitment of the organization, company personnel have to develop new skills associated with successful exporting, and be totally aware of the vagaries of product classification, packaging requirements and so forth. All in all, it is clear that small OS&T firms experience heavy demands on their financial and human resources when they are forced into seeking out export markets for their products early in their development.

LACK OF AN EFFECTIVE INDUSTRY ASSOCIATION

In California's Silicon Valley over 50 different trade associations represent the 2500 companies located there. Currently there is no specific umbrella association for the OS&T Sector in British Columbia, although a secondary objective of the provincial government sponsored Marine Robotics Committee is to form one. A general reluctance to establish such an association may stem from the independent attitude of many OS&T entrepreneurs, or from a lack of recognition of the potential benefits of cooperative effort.

Some firms do belong to associations, established on a wider industry basis - for example, the Electronic Manufacturers Association of British Columbia (EMABC), which provides services including: acting on the collective behalf of members; providing a forum for discussion of common problems; pursuing marketing initiatives; publishing a monthly newsletter (Emanator) and directory; attending trade shows; and sponsoring a speaker luncheon program.

Other established associations exist and include the Vancouver Island Technology and Research Association (VITRA), the Canadian Advanced Technology Association (CATA), the Canadian Manufacturers Association (CMA), the Canadian Federation of Independent Business (CFIB), the Marine Technology Society (MTS), and the Canadian Environment Industry Association (CEIA). All have OS&T Sector firms as members.

Given the diverse products and services produced by the OS&T Sector, a single association may not be practical. Other problems in establishing an association include: high membership dues, for example in CATA dues range from $500 to $15000 annually depending on gross sales; the free-rider problem which occurs because some benefits of an association accrue to all firms not just members; and the fact that the policy stance put forward by the association may not be totally consistent with an individual firm's perspective.

The potential advantages of establishing the equivalent of a British Columbia OS&T Industry Association could include: a single focused voice to better deal with governments; a higher profile for the industry; provision of shared marketing and technical services; and

coordinated information about the industry aimed at the investment community, with an emphasis on publicizing successful risk takers.

LACK OF BASIC INDUSTRY INFORMATION

The quantity and quality of data and information on the OS&T Sector is inadequate. Basic information with respect to volume of sales, markets, market shares, employment, level of R&D expenditures, debt load, and areas of product specialization are generally lacking. Such data are required and need to be continuously updated if government and private sector investors are to make informed business decisions.

FUTURE DIRECTIONS

This report provides a broad overview of the Ocean Science and Technology Sector. The next logical step will be the acquisition of financial and economic information required to promote growth and competitiveness in the Sector. To address this issue, DFO is proposing to initiate a cost and earnings survey as the next step.

To assess the financial performance of any industry sector analysts compare profit levels to the amount of capital invested. To obtain this information, analysts will stratify firms by size and primary activity, and randomly select a sample number of companies in each category to contact. They will then analyze company income statements, balance sheets and asset values to assess financial performance.

The analysis will be instrumental in identifying factors critical to the financial performance of OS&T companies and the Sector in general. Access to capital, the impact of changing market conditions, currency exchange rates, interest rates and government programs will be assessed in terms of their impact on the viability of the industry. Armed with this information, DFO will be in a position to ensure that an adequate type and level of support is provided to the British Columbia OS&T Sector.

While specific company information provided in the survey will be held strictly confidential, industry wide performance will be summarized in a report which will be provided to industry. Firms participating in the survey will also be given aggregate financial data for comparable firms against which they can measure their performance.

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APPENDIX 1

BRITISH COLUMBIA OS&T SECTOR DIRECTORY

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INTRODUCTION

This appendix presents a directory of British Columbia OS&T companies developed in early 1988. Because the Sector does not fit into a traditional industry classification, identifying OS&T companies is difficult.

This OS&T Sector is defined to include "all companies offering a service or producing a product that is oceans related and either, research oriented or dependent on advanced technology". The OS&T Sector excludes companies in the marine equipment and supply sector. For example, products such as radar and depth sounders are considered standard technology and do not meet the requirements for inclusion. Fish processing, shipbuilding, ship repair, and commercial boat builders (other than manufacturers of submersibles and remotely operated vehicles for scientific applications) are also excluded along with those firms whose primary activity is in oil field and non-marine offshore supply.

DIRECTORY

Four sources were used to identify OS&T Sector companies. They include: Growth of the Local Marine Science and Instrumentation Companies Surrounding IOS and Update (Curran 1987); Draft B.C. Offshore Directory (Ministry of Economic Development); British Columbia Manufacturer's Directory (Ministry of Economic Development 1987); and the Vancouver Island Advance Technology Directory (University of Victoria 1987). These sources provided basic information on the 130 British Columbia companies including address, telephone number, number of employees, parent company, key executive and type of product or service. See Table 3.

The average employment across the 103 companies for which data are available is 18.3. Five large companies including Conair Aviation (with 350 employees), Golder Associates (with 51 employees), Morrow Engineering (with 50 employees), McElhanney Group (with 250 employees), and Sandwell Swan Wooster (with 800 employees) were excluded, because only a small portion of their workforce is directed at the oceans industry.

Table 4 shows the distribution of companies by the number of employees. 63% of the companies have fewer than 10 employees, while 80% have fewer than 25 employees.

Approximately 19% (25) of these companies are subsidiaries of larger companies. Table 5 shows the geographic location of these parent companies.

Table 6 shows the geographical location of British Columbia OS&T Sector companies. 55% are located in the Greater Vancouver Area, 34% are located in the southern Vancouver Island Area and the remaining 11% are located in other parts of British Columbia.

LIMITATIONS

Since development of this directory relied on existing sources of information, inclusion of companies was dependant on the product and service description available in existing sources. This directory likely includes most companies whose primary products and services are ocean related and either research-oriented or dependant on advanced technology but may inadvertently exclude companies whose activities comply with the above definition but whose ocean-related activities represent only a small proportion of their total activities.

TABLE 3

OS&T SECTOR DIRECTORY

COMPANY NAME	LOCATION	PRODUCTS AND SERVICES	
Aanderaa Instruments Ltd.**	Victoria	Oceanography, meteorology instr.	Solid state current meters
Advanced Circuit Design Corp.	Victoria	Temperature, water level recorders	
Adventure Vehicle Dynamics	Surrey	Design of printed circuit boards	
AGO Environmental Electronics	Victoria	Recreational submarine	
Alpha Engineering Ltd.	North Vancouver	Oceanographic, hydrographic equip.	
Analytic Systems Ware Ltd.*	Vancouver	Computer hardware	
Aoxoa Computing	Sidney	Meteorological equipment	Electronic equipment, gauges,instruments
Apocalypse	Victoria	Computing services	
Applied Microsystems Ltd.	Sidney	Image processing system software	
Aqua Diving International	Vancouver	Geophys., meteorological instr.	
Aqua Guard Sales Inc.*	Vancouver	Diving services	Single & multi-function recording instr.
Archipelago Marine Research	Victoria	Manufacture oil spill equipment	Skimmers & Cleaners
Arctic Offshore Design		Engineering, environmental consltg.	
Arctic Sciences Ltd.	Vancouver	Consulting - fisheries/aquaculture	Inshore biological & scuba surveys
Artisan Fibertec	Sidney	Marine resource inventory	
Autonectics	Surrey	Naval and marine Architecture	
A/D Computing Instruments	Victoria	Consulting - physical oceanography	Ice research
Ballard Technologies Corp.	Victoria	Aircraft equipment and parts	Submersibles
	North Vancouver	Scientific computing	
Barrodale Computing Services Ltd.	Victoria	Electronic systems	Temp., pressure, salinity, time records
		Advanced portable power systems	R&D engineering for fuel cells/batteries
Bennett Environmental Consultants Ltd.	Vancouver	Solid polymer fuel, lithium batteries	
		Computer systems (VAX)	Computer software development
Broccoli Oceanographic Inc.*	Sidney	Engineering equip. and supplies	
		Consulting - oil spills	Computer mapping systems
B.C. Research	Vancouver	Risk assessments	
C T F Systems Inc.	Port Coquitlam	Oceanographic instruments	Zooplankton sampling
C & B Bateries Ltd.	New Westminster	Titanium water sampler	
Cdn Applied Marine Electronics Ltd.	Vancouver	Oceanographic engineering	
Canadian Battery Corp. Ltd.	Richmond	Electronic instruments	Geophysical instruments
		Marine batteries	
		Electronic equipment	Marine accessories & fittings
		Marine batteries	

TABLE 3 (Cont'd)

OS&T SECTOR DIRECTORY

COMPANY NAME	LOCATION	PRODUCTS AND SERVICES
Candel Industries Ltd.	Sidney	Envir. consltg & manufacturing
Canflex Manufacturing	West Vancouver	Oceanographic data analysis Offshore salvage Inflatable pipe plugs
Canocean Engineering Ltd.*	New Westminster	Subsea and offshore engineering
Canpac Divers Inc.	North Vancouver	Diving services
Can-Dive Services Ltd.	North Vancouver	Underwater diving contractor
CBR International Corp.	Sidney	Marine construction Environmental assess./monitoring
Coast Pilot	Sidney	Novel anti-fouling additive
Coastline Environmental Services	Sidney	Hydrographic surveys
Comdev Marine Electronics Ltd.	Vancouver	Consulting/environmental Modelling
Comex Marine Services Ltd.*	Port Moody	Electronic instruments
Compunav Systems Ltd.	Vancouver	Telerobotic maintenance systems
Comtec Industries Intl.	Vancouver	Electronic equipment
Conair Aviation Ltd.	Abbotsford	Develop prototype microcomputer Specialty aviation services
Control Technologies Inc.	Richmond	Aerial spray oil spill dispersants
CPRO	Victoria	Robot systems & manipulators
Cramer Engineering Ltd.	Vancouver	Modelling
Daleth Computing	Sidney	Electronic equipment/instruments
Daniels Electronics Ltd.	Victoria	Computing services
DF Dickins Associates Ltd.	Vancouver	Communications equipment Environ. Consulting
Dobbs, A.	Sidney	Oil spill impacts & countermeasures
Emco Technology	Saanich	Consulting - oceanographic
ESL	Vancouver	Applied chemical techniques
EVS Consultants	North Vancouver	Inventory of marine plankton data
Fisher Technologies Ltd.*	Victoria	Consulting - aquatic resources
Fitzwright Company Ltd.	Surrey	Sales of oceanographic instruments
Fraser Burrard Diving Ltd.	Richmond	Diving apparatus & supplies
Galatea	Sidney	Commercial marine underwater work
GEC Canada	Burnaby	Commercial potential of galatheid Instruments

Loran-C drifting buoys

Subsea lifting bags

Subsea completion systems & hardware

Offshore oilfield services

Environmental Testing Lab

Toxicity testing
Marine accessories & fittings
Systems engineering
Marine accessories & fittings

Manufacture aerial spray systems

Computer software packages

Scientific instruments & repair

Radio (SSB) and telephone Equipment
Library satellite image files

Data collection & compilation

Computer maps

Consulting - oceanographic

Salvage and Construction

TABLE 3 (Cont'd)

OS&T SECTOR DIRECTORY

COMPANY NAME	LOCATION	PRODUCTS AND SERVICES	
George May & Associates	Sooke	Telesketch graphics phone	Communications equipment
Godek Developments	Sidney	Subsea acoustics	
Goertz, Frederick Ltd.	Vancouver	Consulting - personnel/business plans	
Golder Associates*	Vancouver	Instruments, scientific	
Goode D.	Sidney	Civil offshore mining/indust. projects	
G.A. Borstad Associates Ltd.	Sidney	Support services and laboratory	Lab. for testing materials
Hyco Submersibles*	Vancouver	Marine remote sensing and consulting	
Hymax Engineering Ltd.	Surrey	Subsea tourism w/acrylic submarines	Airborne water/colour/temp. map system
Ice Marine Consultants	Vancouver	Crane lding with motion comp.	Gemini (8 pass.) & Aries (46) class subs.
Innovative Devices Inc.	Sidney	Naval and marine architecture	
Interact Research and Development	Victoria	Microcomputer systems manufacture	
International Hardsuits Ltd.*	North Vancouver	Remote ultrasonic stream gage	
Int'l Statistics & Research (ISR) Corp.		One atmosphere diving (newtsuit)	
Int'l Submarines Engineering Ltd. (ISE)	Brentwood Bay	Manufacture & test facilities	Deep Rover,
	Port Moody	Statistics	
IS Engineering Research*		Tethered submersibles (ROV's)	
IS Entertainment Vehicles*	Port Coquitlam	Underwater acoustic equipment	Design & produce manipulator arm
Jasco Research Ltd.	Vancouver	AUV's	
LGL Ltd Environmental Research Ass.	Sidney	Tourist submarines	ARCS (Sea Horse) and Dolphin (Sea Lion)
Macrotech Computer Products Ltd.	Sidney	Consulting - oceanography	
Martech International	Surrey	Ecology Beaufort Sea	Instruments: spectrometer
McLaren Plansearch Ltd.*	North Vancouver	Computer hardware and software	
Mesotech Systems Ltd. *	Vancouver	Offshore oil diving services	Electronic equipment
	Port Coquitlam	Environmental consultants/planners	
Meteor Communications Ltd.		Design/manufacture acoustic systems	Oceanography and Weather forecasting
Micra Systems Ltd.	Victoria	High resolution imaging sonar	Communications equipment
Microics Industries	Burnaby	Meteor burst communications equip.	
Miller Engineering Surveys Ltd.	Richmond	Communications equipment	Automatic weather stations
Morris Industries Ltd.	North Vancouver	Instruments	Computer hardware and software
Morrow Engineering Ltd.	North Vancouver	Surveys - offshore, seismic	Electronic equipment
	North Vancouver	Oil spill recover equipment	
Newtec Industries Ltd.		Consulting engineering/environ.	
	Burnaby	Marine structures	Oil spill countermeasures & cleanup
		Diving apparatus & supplies	Electronic equipment and Instruments

TABLE 3 (Cont'd)

OS&T SECTOR DIRECTORY

COMPANY NAME	LOCATION	PRODUCTS AND SERVICES	
Nexus Engineering Corp.	Burnaby	Communications equipment	Electronic equipment
Northwest Hydrographic Surveys Ltd.*	Surrey	Consulting - Hydrography	Bathymetric surveys
Novatech Designs Ltd.	Victoria	Electronic/Meteorological instruments	Xenon flashers
Oceanetic Measurement Ltd.	Sidney	Testing of active drifter	
Oceanprobe Systems Mfg. Inc.*	Sidney	Computer aided circuit board design	Acoustic instrumentation
		Acoustic scintillation flowmeter	
Odysseas	Vancouver	Transfer of physical liminology data	
Offshore Systems Ltd.	North Vancouver	Integrated navig. systems/software	PINS 9000, Subsea acoustics
Orca Electronics Engineering Ltd.	Coquitlam	Electronic Design and construction	
Orcatron Manufacturing Ltd.*	Delta	Underwater communications equip.	Scubaphone and Subphone
Pachena Scientific Industrial Electronic	Vancouver	Electronic equipment/instruments	
Pacific Automation Instruments Ltd.	Vancouver	Instruments	
Pacific Fisheries Research & Devel.	Richmond	Trawl system for flying squid	
Pan Canadian Consultants	North Vancouver	Butane stripping contaminants from water	
Panergon Canada Ltd.	Victoria	Underwater camera mount	
Polar Tech Ltd.	Sidney	Consulting - electronic/engineering	160 Channel data logger
		Elect. equipment/Computer syst.	
Premier Geophysics Ltd.	Vancouver	Meteorological instruments	
Quester-Tangent Corporation	Victoria	Consulting - hydrography	ISAH, integrated system auto.hydrography
RMS Industrial Controls*	Port Coquitlam	Remote telemetry	Controls & communic. equip. for ROV's
		Skeda systems	
Robinson Dames & Moore	North Vancouver	Consulting - engine./environ.	Offshore island design
		Geotechnical investigations	
Robotic Systems International Ltd. (RSI)	Sidney	Underwater & land based robots	Custom design robots & control systems
		Kodiak 1000 master/slave manipulators	
Sabre Electronic Instruments Ltd.	Burnaby	Instruments	Map-reading instruments
Sandwell Swan Wooster Eng. Ltd.*	Vancouver	Consulting/engineering	
		Ofshre. struct/design	
Seaconsult Marine Research Ltd.	Vancouver	Consulting- engineering/oceanography	Computer system
		Oceanographic field equipment	
Seakem Oceanography Ltd.	Sidney	Underwater instrumentation	Meteorological instrumentation
Seastar Instruments*	Sidney	Subsea acoustics	Telemetry, eg., acoustic releases
		Fibre optic devices	
Seaway Manufacturing Co. Ltd.	Surrey	Diving apparatus & supplies	

TABLE 3 (Cont'd)

OS&T SECTOR DIRECTORY

COMPANY NAME	LOCATION	PRODUCTS AND SERVICES	
Sea-I Research Canada Ltd.*	Sidney	Linear ROV survey vehicles (Manta)	Electronic equipment
Softek Systems	Vancouver	computerized databases	Computer software
Spilsbury Communications	Vancouver	SSB radiotelephones	
Sub Aquatic Development Corp.	Vancouver	Tourist submarines Tourist franchise turnkey operations	Aquarius (28 pass.) class subs
Submarine Enterprises	Vancouver	Diving Services	
Sy-tech Research Ltd.*	Sidney	Oceanographic instruments Acoustic transducers	Data acquisition systems
Techwest Enterprises Ltd.*	Richmond	consulting- engineering	Instruments, Satellite communications
Tele-radio Systems Ltd.	North Vancouver	Communications equipment	Electronic equipment
Terra Surveys Ltd.*	Sidney	Consulting-hydrographic/geophysical High resolution seismic studies	Offshore survey & positioning
The Environment Centre (TEC)	Vancouver	Consulting - environmental Oil spill control equipment	Computer systems
The McElhanney Group Ltd.	Vancouver	Consulting/survey/mapping Navigation & positioning	Hydrography, Engineering
TIAC Systems Ltd.	Port Moody	Telemetry system design/manufact. L.A.N. systems	Computer based electronics
Triton Consultants	Vancouver	Consulting Engineering Offshore structure dynamics	Model wave dynamics, tides.
Tropical Submarines Safaris	Vancouver	Subsea tourism (Odyssey submarine)	Franchise turnkey operations
Versatech Products Inc.	Burnaby	Manufacture of oil spill equipment Oil skimmers	Oil spill containment/recovery systems
Wardell Aqua Comfort Ltd.	Burnaby	Manufacture diving/survival suits	
Western Canada Hydraulic Laboratories*	Port Coquitlam	Consulting & applied research	Wave tank and flume testing
Western Ecological Services Inc.	Victoria	One dimensional carbon analysis	Consult. - Botany/forestry/land use
Western Subsea Technology Ltd.	Victoria	Consulting - engineering	
Walker Industrial Computing	Sidney	Computing services	Modifications to BERT 101

* Designates company as subsidiary
** Common Shareholders

TABLE 4

EMPLOYMENT DISTRIBUTION

Number of Employees	Number of Companies	Percentage of Companies
1-10	62	62.6%
11-25	17	17.2%
26-50	15	15.2%
51 +	5	5.0%
Total	99	100%

* Employment data for 26 companies were unavailable. Employment data for 5 large companies were excluded because only a few of their employees were involved in OS&T Sector activities.

TABLE 5

GEOGRAPHIC LOCATION OF PARENT COMPANIES

Geographic Location	Number of Parent Companies In Each Location	Average # of Employees of British Columbia Subsidiaries
B.C.	11	49.8
Rest of Canada	7	8.7
Foreign	7	12.8
Total	25	23.9

TABLE 6

LOCATION OF OS&T COMPANIES WITHIN BRITISH COLUMBIA

LOCATION	# OF COMPANIES	% OF TOTAL
Greater Vancouver	71	54.6
Vancouver	31	23.8
North Vancouver	14	10.8
Burnaby	7	5.4
Port Coquitlan	6	4.6
Surrey	6	4.6
Richmond	7	5.4
Southern Vancouver Isl.	44	33.9
Sidney	26	20.0
Victoria	18	13.9
Other	15	11.5
Total	**130**	**100.0**

APPENDIX 2

SUMMARY OF CANADA'S OCEANS STRATEGY

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CANADA'S OCEAN STRATEGY

DFO recently published the "Oceans Policy for Canada: A Strategy to Meet the Challenges and Opportunities on the Oceans Frontier" (1987). This appendix summarizes the rationale for the Strategy and identifies goals and proposed action plans.

There are three compelling reasons why Canada needs an Oceans Strategy.

1. Canada has extensive oceanic territories. A strategy will ensure Canadians can capitalize on the many development opportunities on this frontier, especially during the critical next five years.

2. There is currently a broad range of federal oceans policies and programs. A framework is needed to ensure that they are coordinated, effective, and efficient.

3. This strategy provides a tangible means of moving forward on major federal priorities - regional development, world-class science and technology, and protection of Canadian sovereignty.

GOALS

The Government of Canada is committed to achieving four goals through its oceans strategy:

-prosperous, dynamic oceanic industries which offer secure, steady employment and economic development benefits, particularly for Canada's coastal regions;

-world-class expertise and capability in oceans-related science, technology, and engineering, which together form the basis for future economic development of the oceans;

-ocean resources and an ocean environment soundly managed and protected for future generations of Canadians; and

-assertion and protection of Canada's sovereignty and sovereign rights over its ocean resources.

Action Plan

To accomplish these goals, six overall approaches have been adopted, and these in turn involve a large number of specific initiatives. The six approaches are:

i) stimulating national awareness of Canada's oceans frontier and its importance to our sovereignty and heritage;

ii) fostering vigorous, internationally competitive oceanic industries through our industrial development, contracting-out, and procurement policies;

iii) establishing a legal framework which facilities Canada's ability to achieve the objective and goals of this strategy;

iv) enhancing Canada's scientific and technological knowledge and capabilities relating to oceans and ocean resources;

v) conserving and managing the living resources of Canada's oceans through prudent stewardship; and

vi) promoting development and exploitation of the non-living resources of our oceans in an environmentally acceptable manner.

Taken together, the initiatives under each of these categories constitute the oceans strategy action plan. Several of the initiatives require joint and concerted efforts of several Ministers and departments of the Government of Canada. Carrying forward these initiatives will require ongoing consultations with industry, universities, provincial governments and other interests.

This oceans policy has been adopted by the Government of Canada to provide a broad framework for developing the oceans economy in an environmentally sound manner, strengthening science and technology-based oceanic industries and asserting Canadian sovereignty over our oceanic territory.